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THE TRANSMISSION OF NEUTRONS AND GAMMA-RAYS THROUGH AIR SLOTS. PART VIII. THE EFFECT OF THE SOURCE SIZE ON THE NEUTRON TRANSMISSION OF AN AIR SLOT

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THE TRANSMISSION OF NEUTRONS AND GAMMA-RAYS THROUGH AIR SLOTS

Part VIII

The Effect of the Source Size on the Neutron Transmission of an Air Slot

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One of the questions which will be of interest to those who wish to use the information presented in this series of reports, and which may be of interest to others as well, is the effect of the spatial extent of the source on the neutron transmission of an air slot in water. The method which has been chosen to investigate this question takes advantage of the fact that the source plate is continuously movable[1]. The region beneath the slot is scanned with the leading edge of the forty inch square source plate to determine the relative importance of the various parts of the source in supplying the transmitted neutrons. The change in the transmitted flux when the source is moved from position A to position B is a measure of the flux originating in the regions which are not common to both position A and position B.

This report presents the data which have been obtained on the source size effect and a discussion of some measurements which we expect to make in the near future to aid in answering the questions which these data have raised.

The procedure which has been used is described below. The slot was placed in the tank with its short dimension (T) parallel to the direction of motion of the source plate. A typical arrangement is shown in Figure 1. The forty inch square source plate was then moved in small steps under the tank. For each position of the source plate, either the fast neutron dose or the thermal neutron flux, or sometimes both, was measured in the water at a point above the center of the slot. The resulting curves were differentiated graphically to give the contribution to the transmitted flux or dose by various line elements of the source. One set of data was also obtained with the slot rotated through ninety degrees so that the larger of the horizontal dimensions (W) was parallel to the direction of motion of the source.

Most of the information has been obtained with a special 3 x 24 x 48 inch slot, shown in Figure 1, which had 0.125 inch steel walls and rested directly on the tank bottom. In addition, one measurement is available with a 1 x 34 x 48 inch slot in the usual slot holder[2].

Figures 2 and 3 contain the data obtained with a BF_3 counter and a Hurst-type nondirectional fast neutron dosimeter above the 3 x 24 x 48 inch air slot. Both detectors were located at Z=62 inches, 13.5 inches above the top of the slot, and both sets of data were obtained at the

[1] A complete description of the mechanical features of the BNL shielding facility appears in BNL-139

[2] A description of the apparatus is given in Part I of this series, BNL-2019

same time. The slopes of these curves, corresponding to the contribution to the measured dose or flux from line elements of the source, have been plotted in Figures 4 and 5. The contribution of the thermal neutron flux and the fast neutron dose from the various regions of the source are quite similar and seem to justify the use to the thermal neutron detector to measure something proportional to the fast neutron dose when a large water separation exists between the top of the slot and the thermal neutron detector. A third set of data using this same slot, which was obtained with a BF_3 counter at Z=64 inches, is shown in Figure 6. The curve obtained by differentiating these data is shown in Figure 7 in which the curves presented in Figures 4 and 5 have been included for comparison. The differences between these curves are probably indicative of the uncertainties in the original data and in the differentiation process used to obtain these curves from the original data.

The region of the source plate subtended by the angle defined by the bottom of the slot and the detector is indicated on each of the figures and is referred to as the region "directly seen" by the detector. For the three inch slot resting on the tank bottom, at least two thirds of the exit flux originated in the region so defined.

The information which was obtained with the 3 x 24 x 48 inch slot rotated through ninety degrees is given in Figures 8 and 9. These data illustrate clearly an asymmetry which is not very apparent in the other curves. When the source plate is centered under the tank, in the so-called "0" position, a small displacement of the source removes a section of the source from one side but adds it to the other side, so that the net change in transmitted neutrons is very small. Soon, however, the source begins to enter a boral lined magazine located just north of the tank, so that further changes in the source position alter the location of only one edge of the effective source. The north edge is determined by the location of the edge of the boral shield in the magazine. These data, while not conclusive, indicate that the contribution to the transmitted flux from those portions of the source not "directly seen" by the detector is quite small.

Unfortunately, the only information which is available for slots which do not rest on the bottom of the tank was obtained with a 1 x 34 x 48 inch slot which is a little too thin to permit a detailed analysis of the data or a direct comparison with the three inch slot resting on the bottom. For this case in which the bottom of the one inch slot was 3.75 inches above the tank bottom, the data are presented in Figures 10 and 11. It is apparent that the contribution to the transmitted flux from the region of the source not "directly seen" by the detector is a larger fraction of the total than was observed with the three inch slot located at the bottom of the tank. We do not have sufficient information at the present time to determine the effect of the distance between the source plate and the bottom of the slot, the effect of the amount of material between the bottom of the slot and the source, or the effect of the slot thickness on the region of the source from which the exit flux originates. It is thought that the additional material between the bottom of the slot and the source plate

is primarily responsible for the increased contribution from regions far removed from the slot rather than the change in slot thickness being primarily responsible. The validity of this belief will be investigated by making measurements with the 3 x 24 x 48 inch slot raised so that there is 3.5 inches of water beneath it. This particular investigation has been postponed because the source plate has become somewhat difficult to move. Measures are being taken to ease the source plate movement.

For all of the measurements the contribution to the transmitted flux from regions of the source which are far removed from the bottom of the duct is not negligible. It should be noted, however, that the source plate is 10.6 inches beneath the bottom of the tank so that neutrons can reach the region of the bottom of the duct from the edges of the source. One would expect then, that the introduction of appreciable scattering material beneath the slot would significantly increase the contribution to the exit flux from the region of the source far from the slot. To ascertain the effect of the separation between the source plate and the tank bottom, a special natural uranium source plate, 2" x 40" x 5/8", is being fabricated. This source will be placed in the tank and moved relative to the slot to determine how the contribution from the line source depends on the separation between the source and the slot.

48" X 24" X 3" STEEL VOID LOCATED AT THE BOTTOM OF BNL SHIELDING TANK

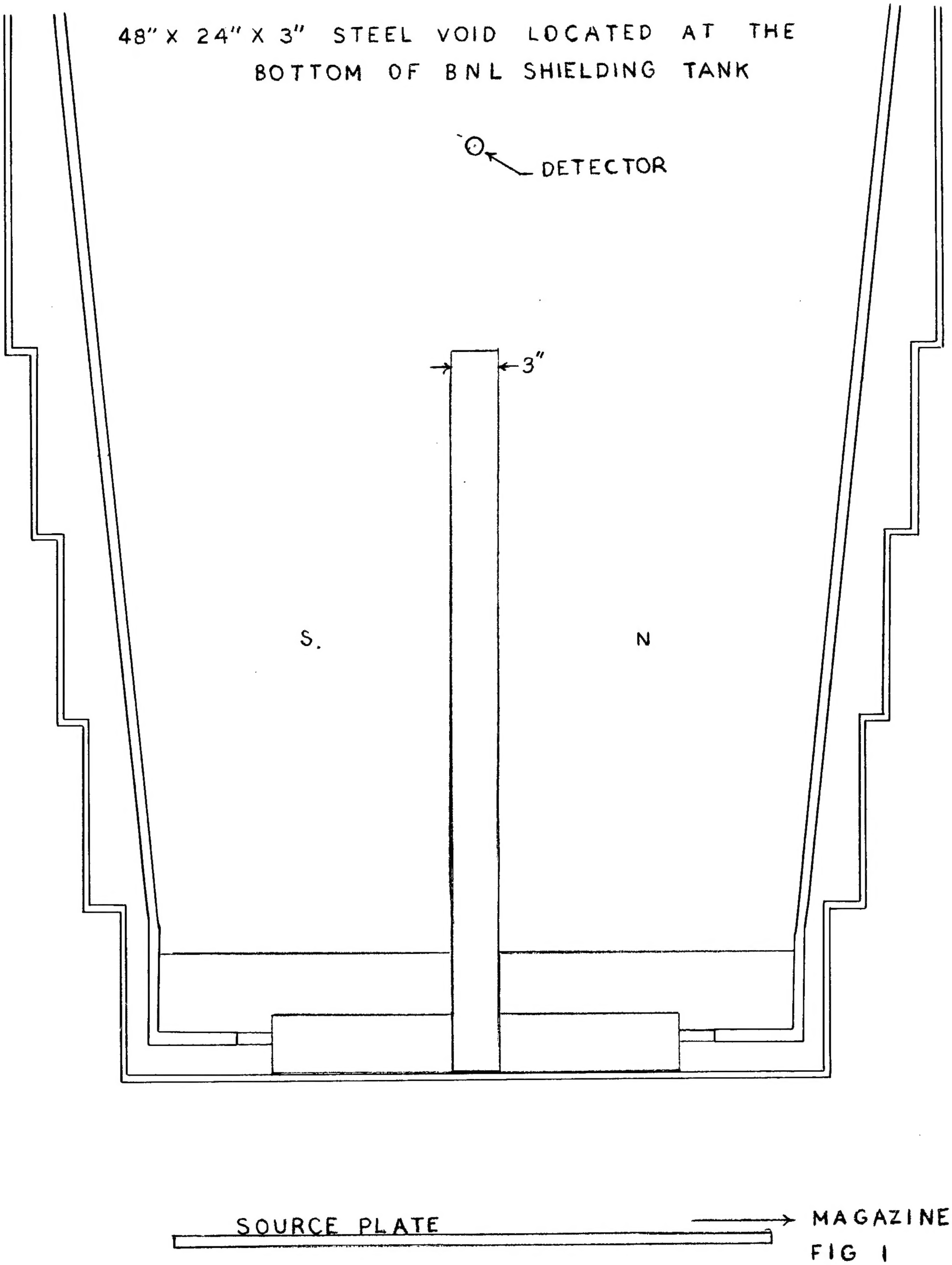
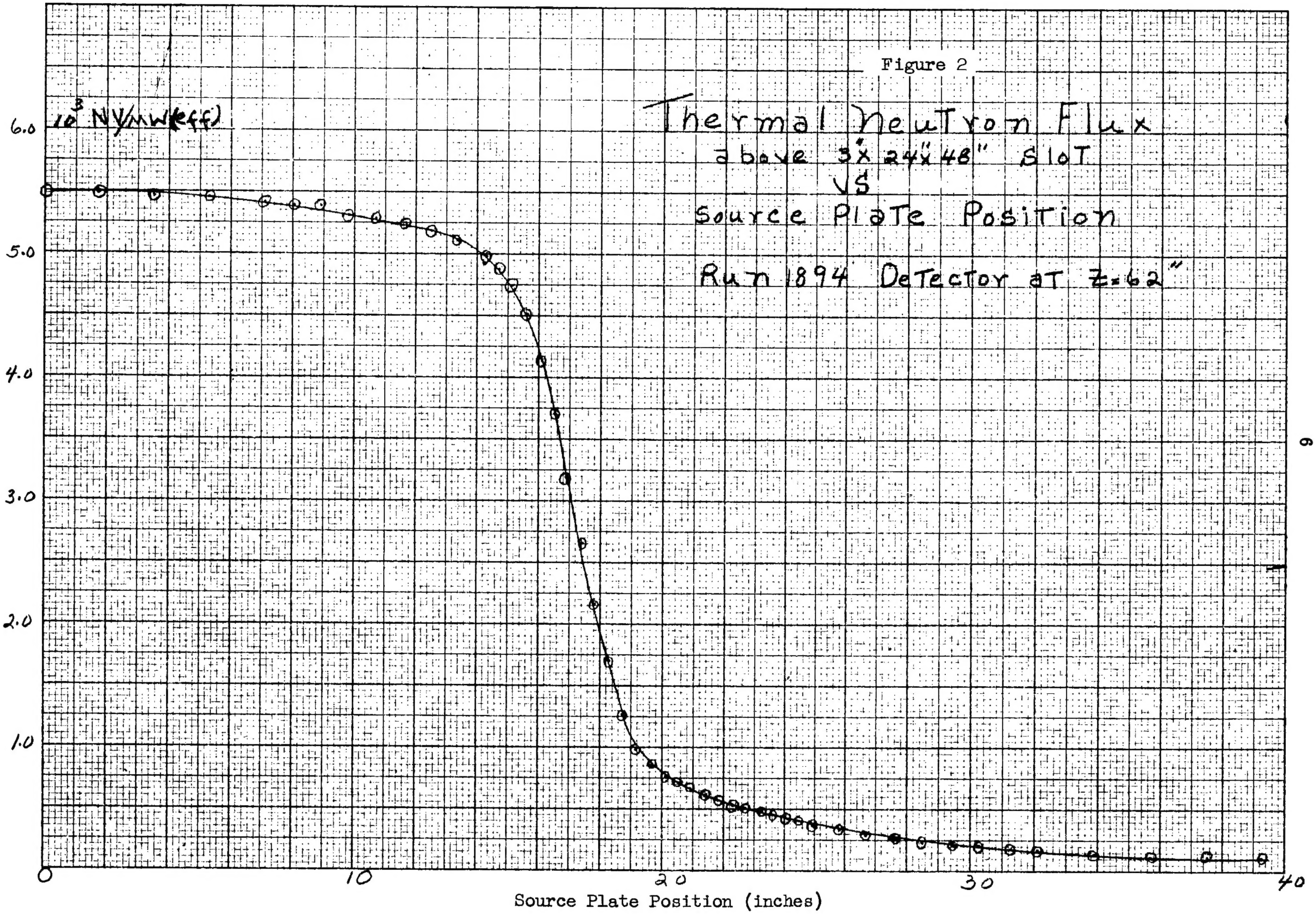


FIG 1



Thermal Neutron Flux
above 3" x 24" x 48" SloT
VS
Source PlaTe Position
Run 1894 DeTecTor aT Z=62"
10^3 NV/MW(eff)
6.0
5.0
4.0
3.0
2.0
1.0
0
10
20
30
40
Source Plate Position (inches)

Figure 2

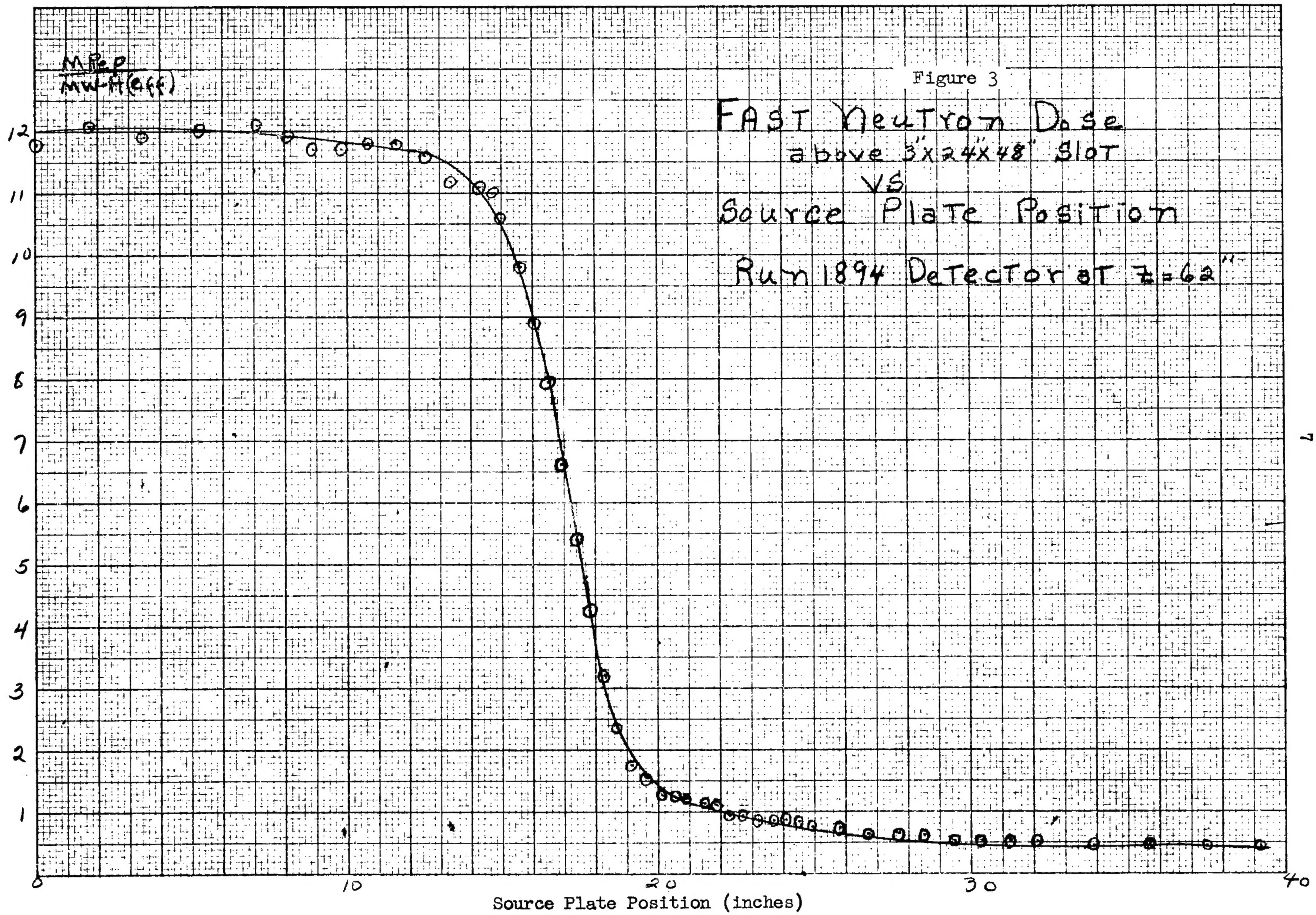

MRep / MW-H(eff)
12
11
10
9
8
7
6
5
4
3
2
1
0
10
20
30
40
FAST Neutron Dose
above 3"x24"x48" Slot
VS
Source Plate Position
Run 1894 Detector at Z=62"
Source Plate Position (inches)

Figure 3

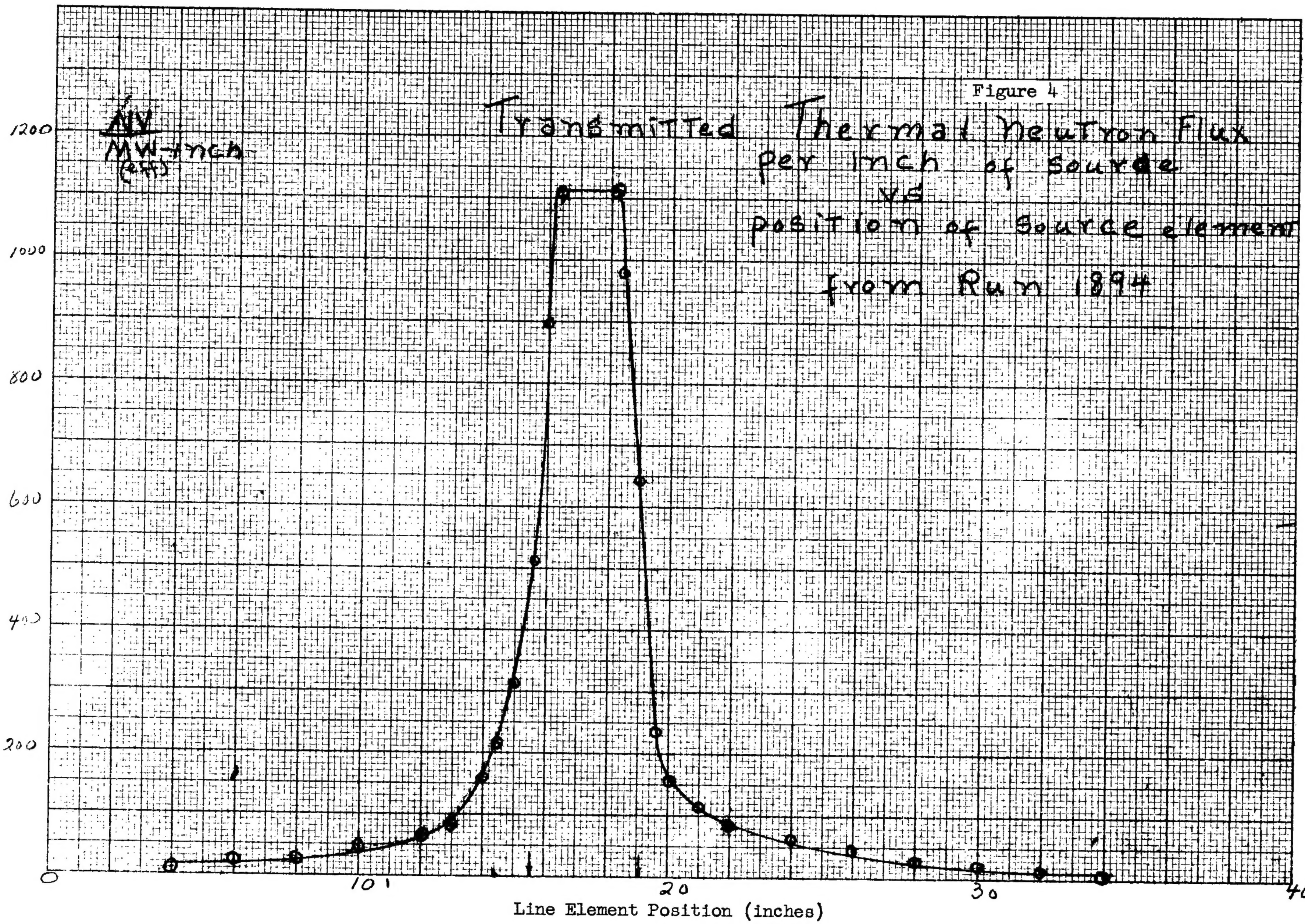

Transmitted Thermal Neutron Flux
per inch of source
vs
position of source element
from Run 1894
nv
MW-inch
(eff)
1200
1000
800
600
400
200
0
10
20
30
40
Line Element Position (inches)

Figure 4

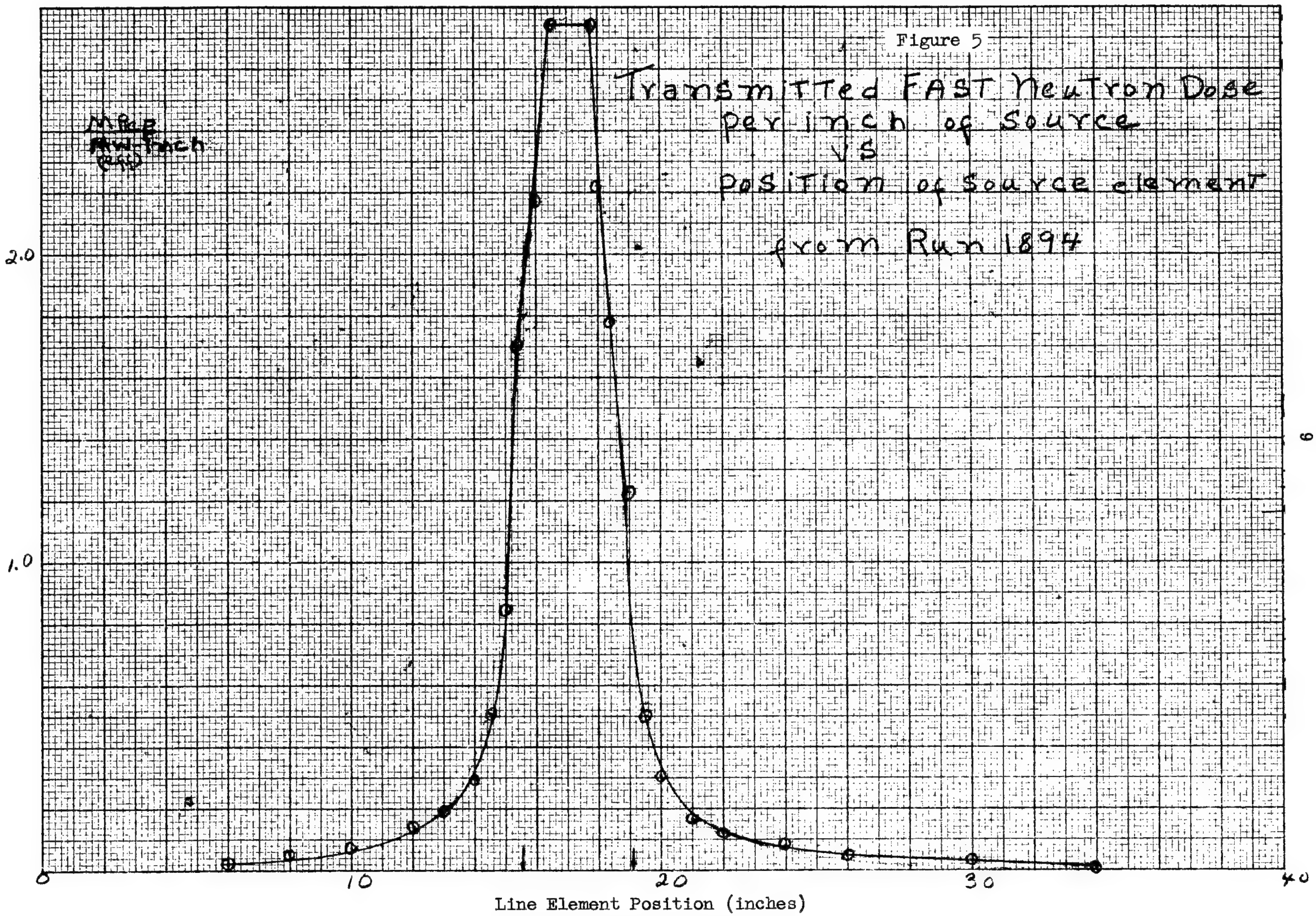


Figure 5
Transmitted FAST Neutron Dose
per inch of Source
vs
Position of Source element
from Run 1894
2.0
1.0
0
10
20
30
40
Line Element Position (inches)

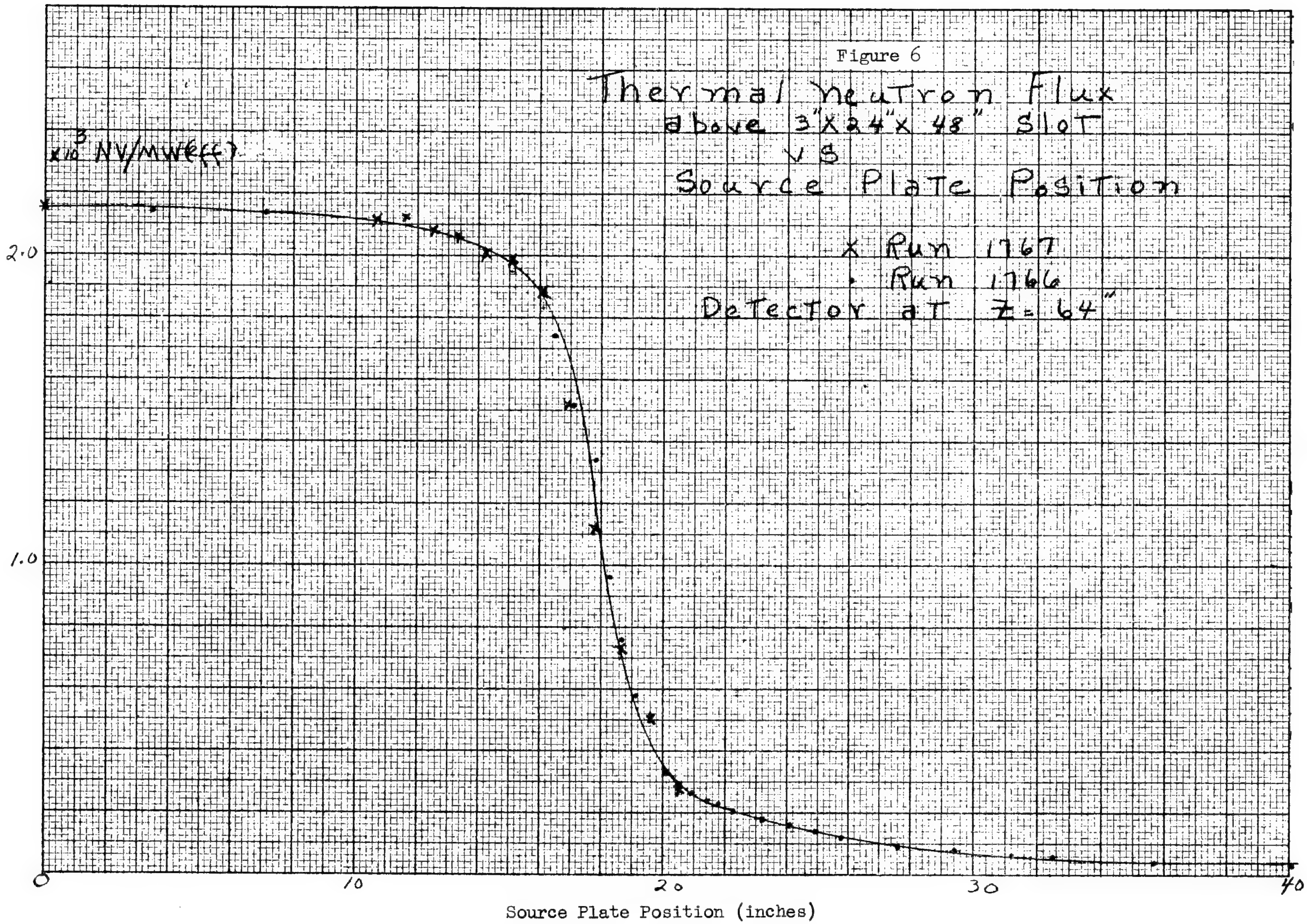
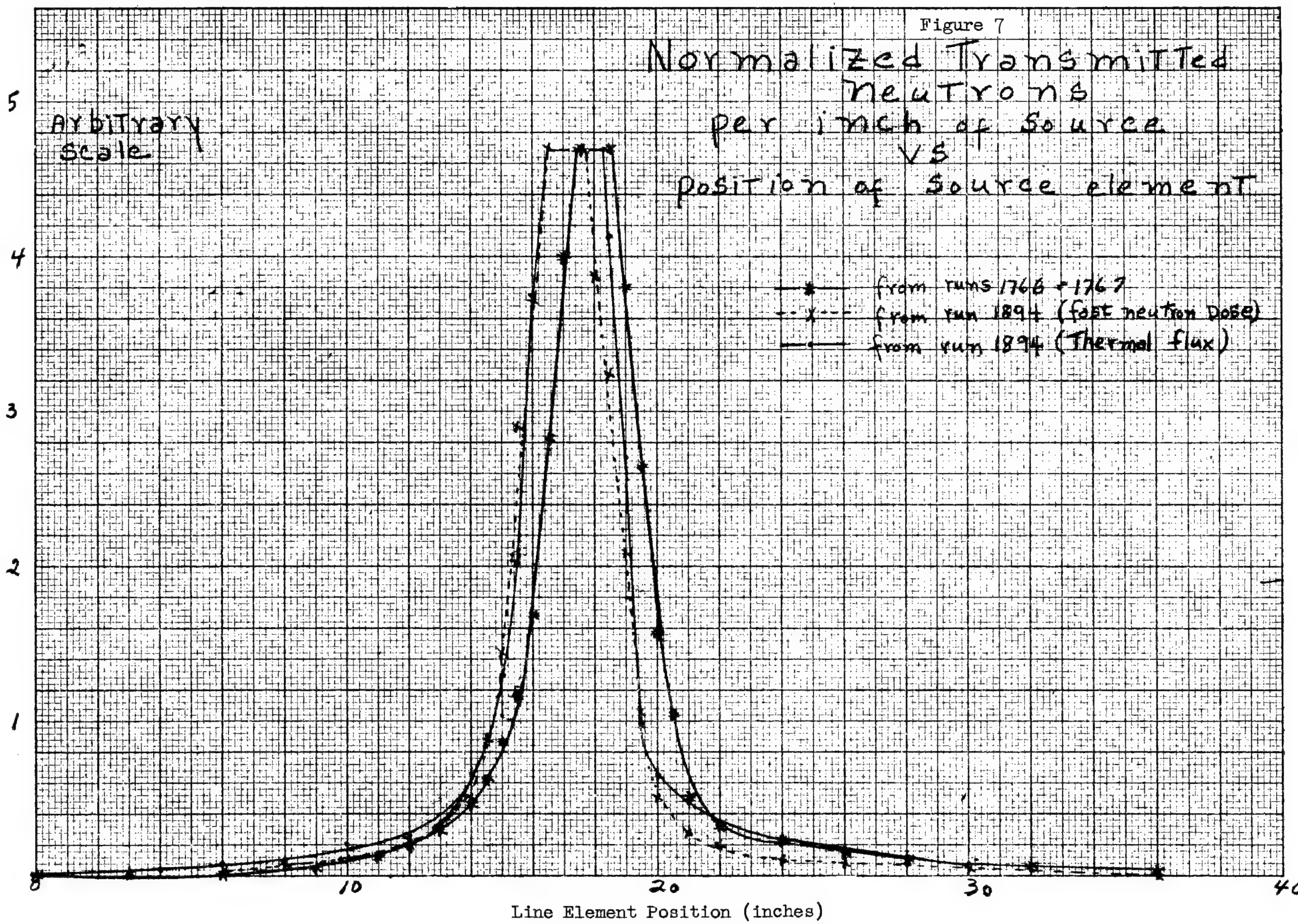
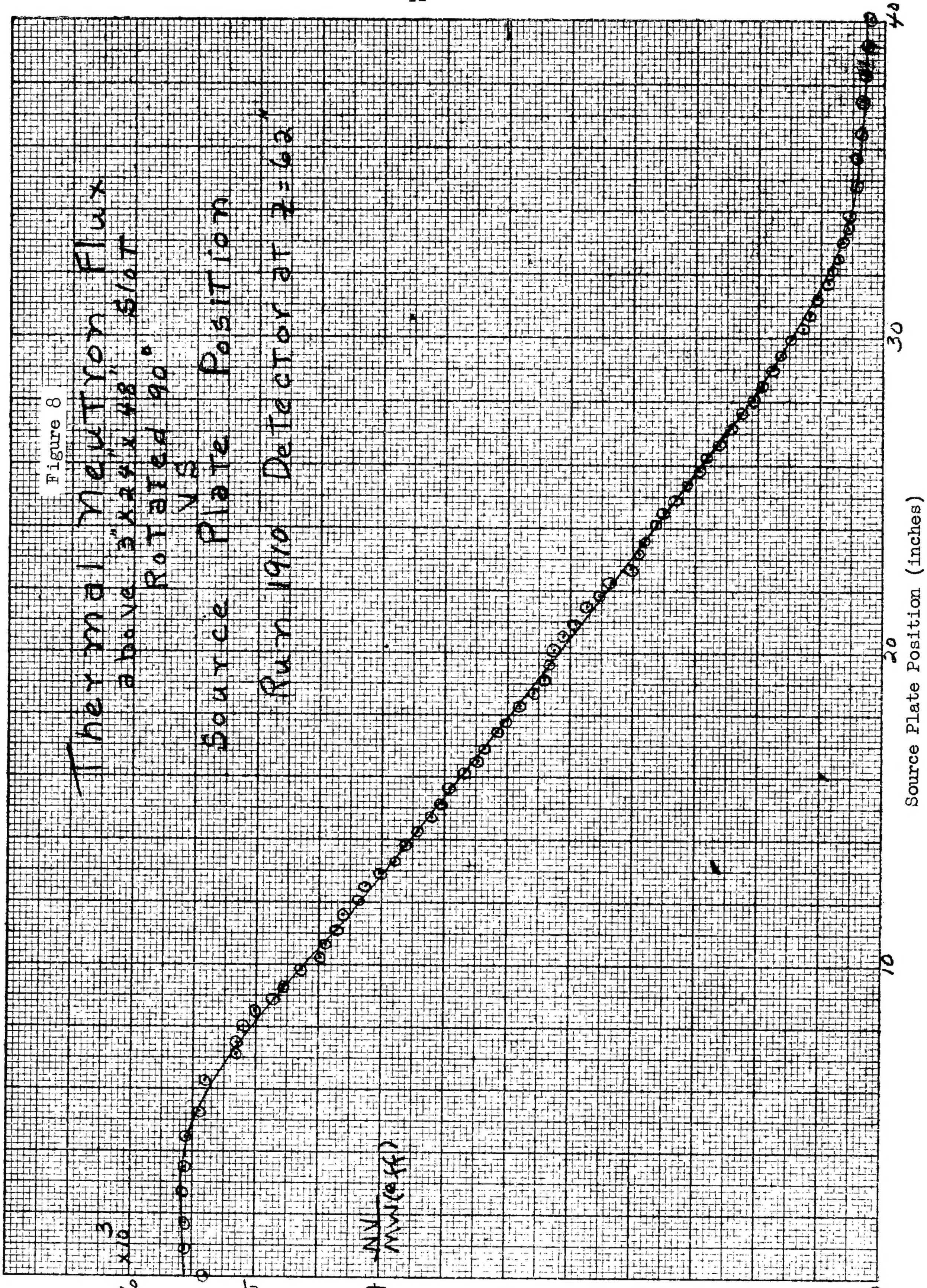

Thermal neutron Flux
above 3"x24"x 48" Slot
vs
Source Plate Position
x Run 1767
· Run 1766
Detector at Z = 64"
x10^3 NV/MW(eff)
2.0
1.0
0
10
20
30
40
Source Plate Position (inches)

Figure 6

Figure 7


Normalized Transmitted Neutrons per inch of Source VS Position of Source element
Arbitrary Scale
5
4
3
2
1
0
10
20
30
40
from runs 1766 + 1767
from run 1894 (fast neutron Dose)
from run 1894 (Thermal flux)
Line Element Position (inches)


Thermal Neutron Flux
above 3"x24"x48" S/O T
Rotated 90°
vs
Source Plate Position
Run 1910 Detector at z=62"
NV/MW(eff)
x10^3
Source Plate Position (inches)
0
10
20
30
40
1
2
3
4
5
6
Figure 8

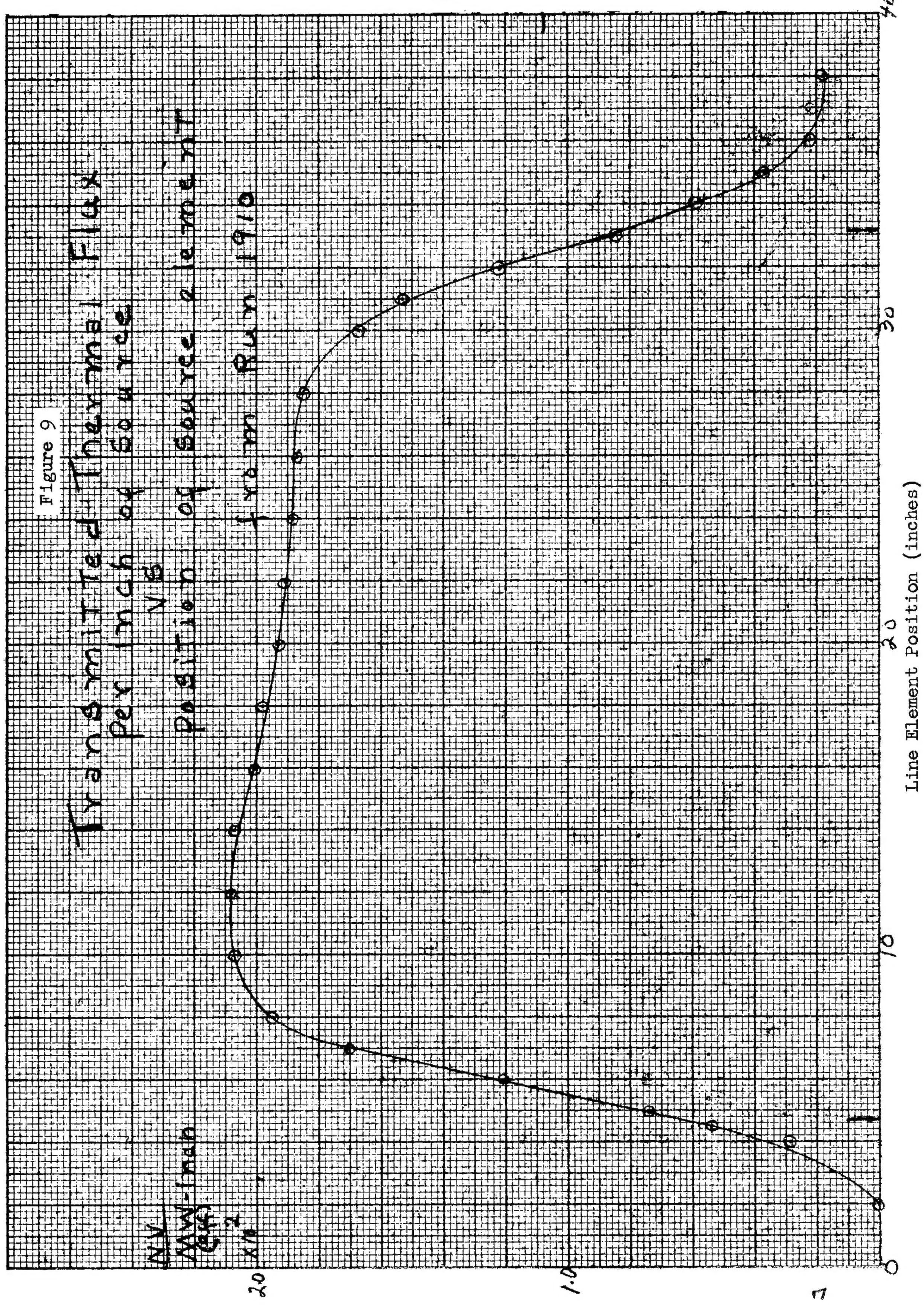
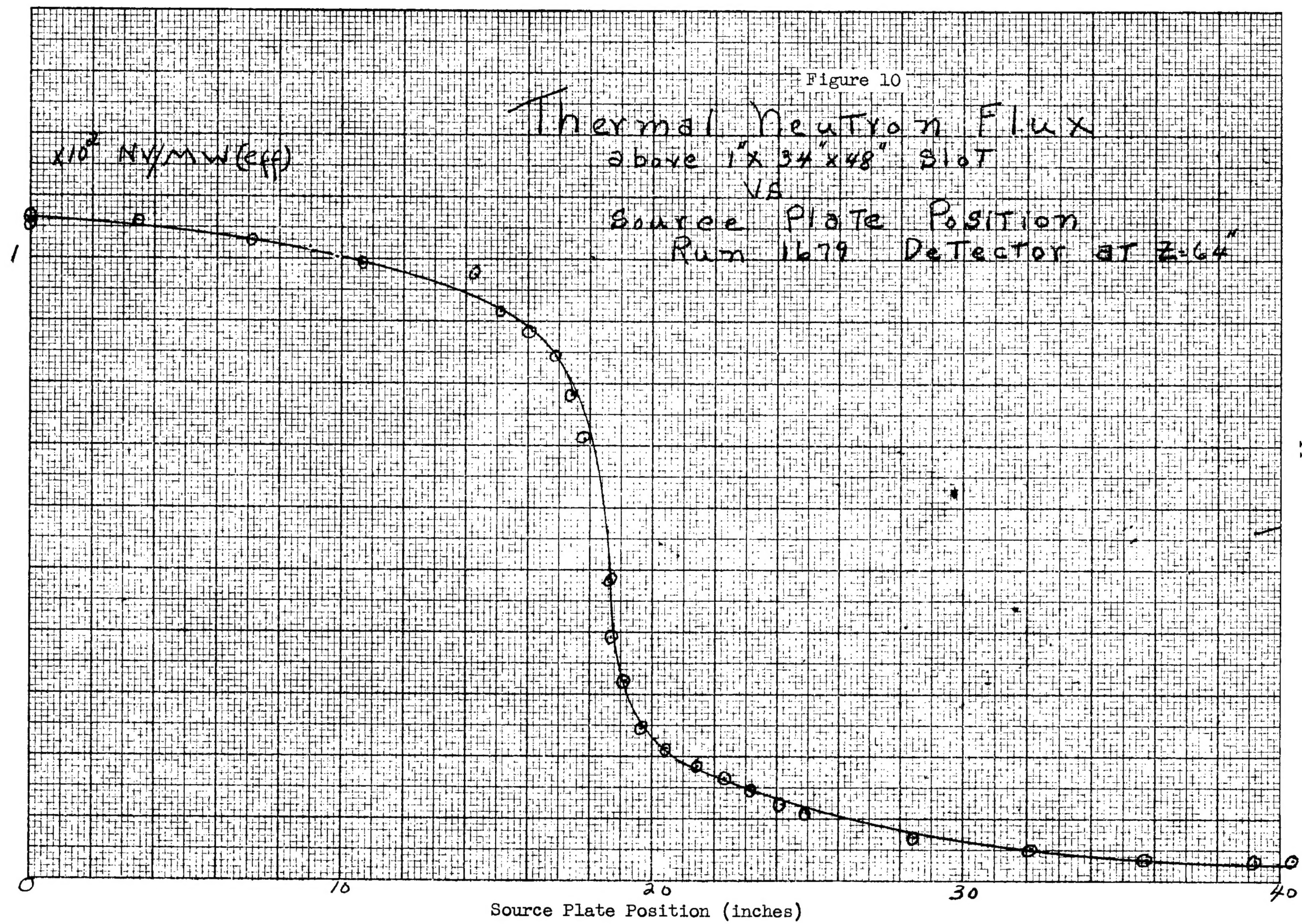
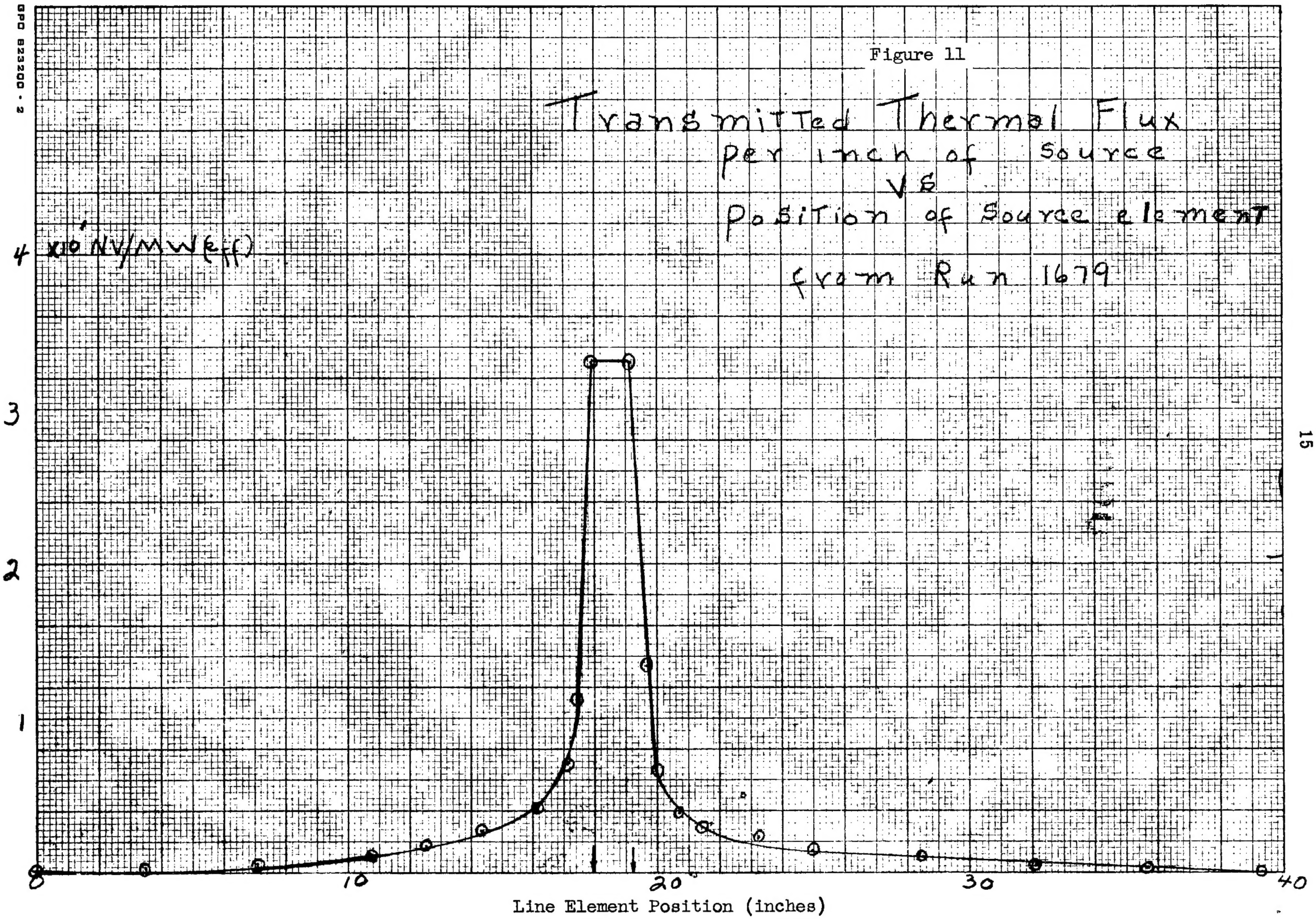

Transmitted Thermal Flux
Per Inch of Source
vs
Position of Source element
from Run 1910
NV
MW-inch (est)
x10^2
2.0
1.0
.7
0
10
20
30
40
Line Element Position (inches)

Figure 9

Figure 10


Thermal Neutron Flux
above 1" x 34" x 48" Slot
VS
Source Plate Position
Run 1679 Detector at Z=64"
x10² NV/MW(eff)
1
0
10
20
30
40
Source Plate Position (inches)



Transmitted Thermal Flux
per inch of source
vs
Position of Source element
from Run 1679
4 x10^{1} NV/MW(eff)
3
2
1
0
10
20
30
40
Line Element Position (inches)

Figure 11